US009329719B2

(12) United States Patent
Mölne et al.

(10) **Patent No.:** **US 9,329,719 B2**
(45) **Date of Patent:** **May 3, 2016**

(54) **HYBRID FORCE SENSITIVE TOUCH DEVICES**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Anders L. Mölne**, Cary, NC (US);
David Griffith, Apex, NC (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/915,267**

(22) Filed: **Jun. 11, 2013**

(65) **Prior Publication Data**

US 2013/0342501 A1 Dec. 26, 2013

Related U.S. Application Data

(63) Continuation-in-part of application No. 13/425,846, filed on Mar. 21, 2012, now Pat. No. 8,780,543, which is a continuation-in-part of application No. 12/450,138, filed as application No. PCT/US2008/003374 on Sep. 11, 2009, now Pat. No. 8,144,453.

(60) Provisional application No. 61/658,020, filed on Jun. 11, 2012, provisional application No. 60/918,275, filed on Mar. 15, 2007.

(51) **Int. Cl.**
G06F 3/041	(2006.01)
G06F 3/044	(2006.01)
G06F 3/045	(2006.01)
G06F 3/042	(2006.01)
G06F 3/043	(2006.01)
G06F 3/046	(2006.01)

(52) **U.S. Cl.**
CPC *G06F 3/0416* (2013.01); *G06F 3/044* (2013.01); *G06F 3/045* (2013.01); *G06F 3/0414* (2013.01); *G06F 3/042* (2013.01); *G06F 3/043* (2013.01); *G06F 3/046* (2013.01); *G06F 3/0418* (2013.01); *G06F 2203/04105* (2013.01); *G06F 2203/04106* (2013.01)

(58) **Field of Classification Search**
CPC G06F 3/044; G06F 3/0414; G06F 3/045; G06F 3/0418; G06F 2203/04105; G06F 2203/04106
USPC 345/173, 174
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,550,384 A	*	10/1985	Kimura	.... G06F 3/0414 178/18.01
5,541,372 A	*	7/1996	Baller	.... G06F 3/0414 178/18.01

(Continued)

FOREIGN PATENT DOCUMENTS

WO WO2011/024461 3/2011

Primary Examiner — Temesgh Ghebretinsae
*Assistant Examiner* — Michael J Jansen, II
(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

(57) **ABSTRACT**

A hybrid touch-screen display that integrates force-based touch-screen technology with any one from among a group of projective capacitive, surface capacitive, resistive, digital resistive, SAW, IR, APR, DST, optical and electromagnetic touch-screen technologies to provide an ability to compensate for non-perfect force transfer. An alternate implementation is also disclosed that employs a single force sensor for relative force measurement in a system in which force is traditionally not measured, here a water dispenser unit. This allows compensation for varying static loads, run-time calibration, and filtering of extraneous loads through firmware.

13 Claims, 3 Drawing Sheets
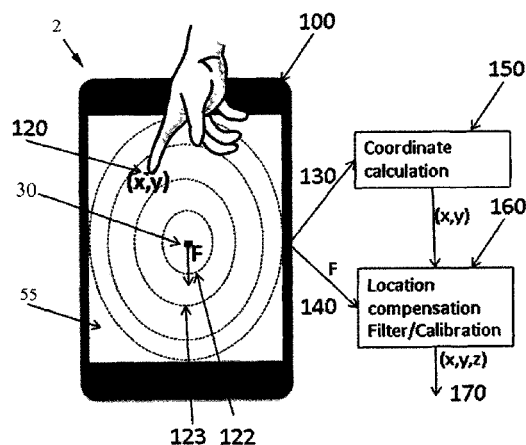
(56) **References Cited**

U.S. PATENT DOCUMENTS

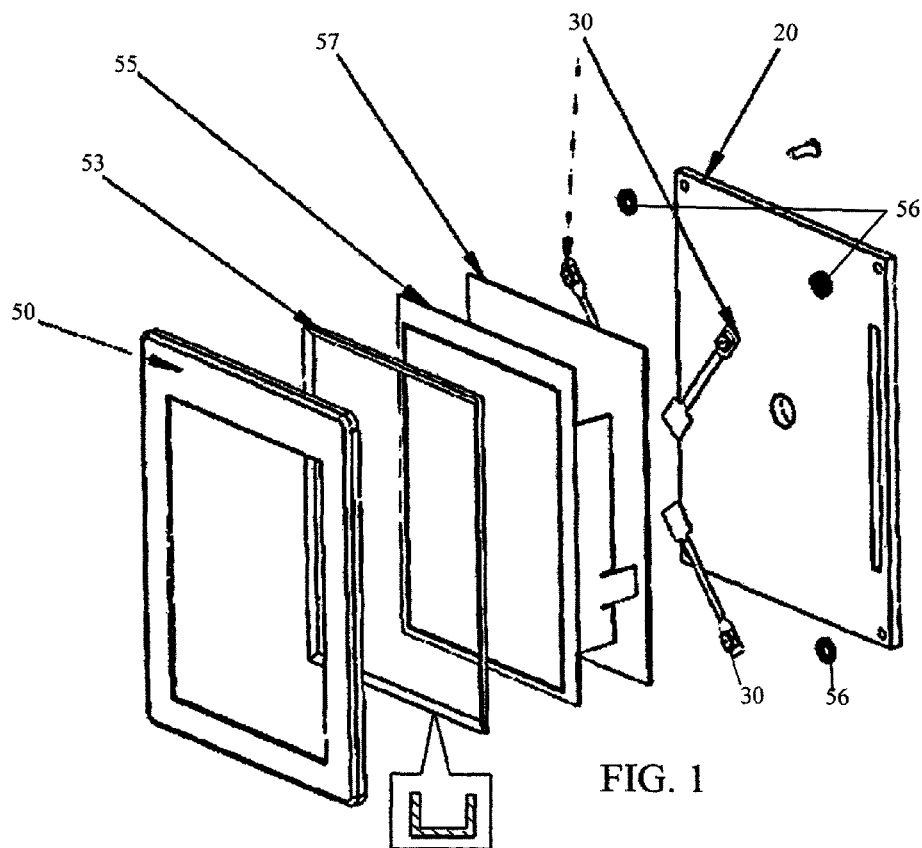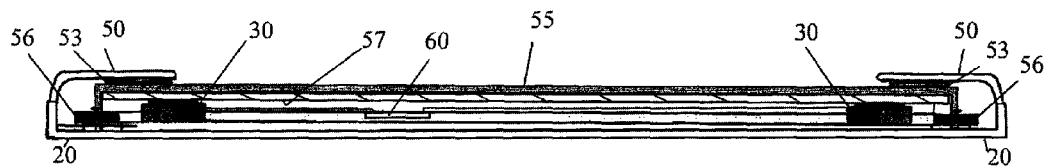|				
6,040,846	A *	3/2000	Stanton et al.	345/76
6,492,979	B1 *	12/2002	Kent et al.	345/173
8,026,906	B2 *	9/2011	Molne et al.	345/174
8,144,453	B2 *	3/2012	Brown et al.	361/679.21
8,169,332	B2	5/2012	Son	
8,270,148	B2 *	9/2012	Griffith et al.	361/679.01
8,421,483	B2 *	4/2013	Klinghult et al.	324/686
8,547,350	B2 *	10/2013	Anglin et al.	345/173
8,780,543	B2 *	7/2014	Molne et al.	361/679.21
2003/0210235	A1	11/2003	Roberts	
2006/0119581	A1	6/2006	Levy	
2006/0181517	A1 *	8/2006	Zadesky et al.	345/173
2006/0279548	A1 *	12/2006	Geaghan	345/173
2007/0119698	A1	5/2007	Day	
2009/0017263	A1 *	1/2009	Yeates	428/167
2009/0066673	A1 *	3/2009	Molne et al.	345/178
2009/0256817	A1 *	10/2009	Perlin et al.	345/174
2010/0045612	A1 *	2/2010	Molne	345/173
2010/0103640	A1 *	4/2010	Brown et al.	361/829
2010/0156814	A1 *	6/2010	Weber et al.	345/173
2010/0178957	A1	7/2010	Chen	
2010/0207906	A1 *	8/2010	Anglin et al.	345/174
2010/0245254	A1 *	9/2010	Olien et al.	345/173
2010/0300772	A1	12/2010	Lee et al.	
2011/0141052	A1 *	6/2011	Bernstein et al.	345/174
2011/0157087	A1 *	6/2011	Kanehira et al.	345/174
2011/0181402	A1	7/2011	Goodrich et al.	
2011/0227872	A1 *	9/2011	Huska et al.	345/174
2011/0284348	A1	11/2011	Nohechi	
2012/0154315	A1	6/2012	Aono	
2012/0200526	A1 *	8/2012	Lackey	345/174
2012/0200789	A1 *	8/2012	Molne et al.	349/12
2012/0327025	A1 *	12/2012	Huska et al.	345/174

* cited by examiner

FIG. 1

FIG. 2

FIG. 3

FIG. 4

2

100

120

F₁ 130

F₂

(x,y)

110

F₃ F₄

30

ProCap Controller
152   150

ProCap
Coordinate
calculation (x,y)

(x,y)

180 zTouch
coordinate
calculation (x,y,z)

(x,y,z)

FSR Controller 190
192

Master Controller
202

200

Touch coordinate (x,y,z)
and force
selection   210

FIG. 5

10

90

40

30   80

60

70

20
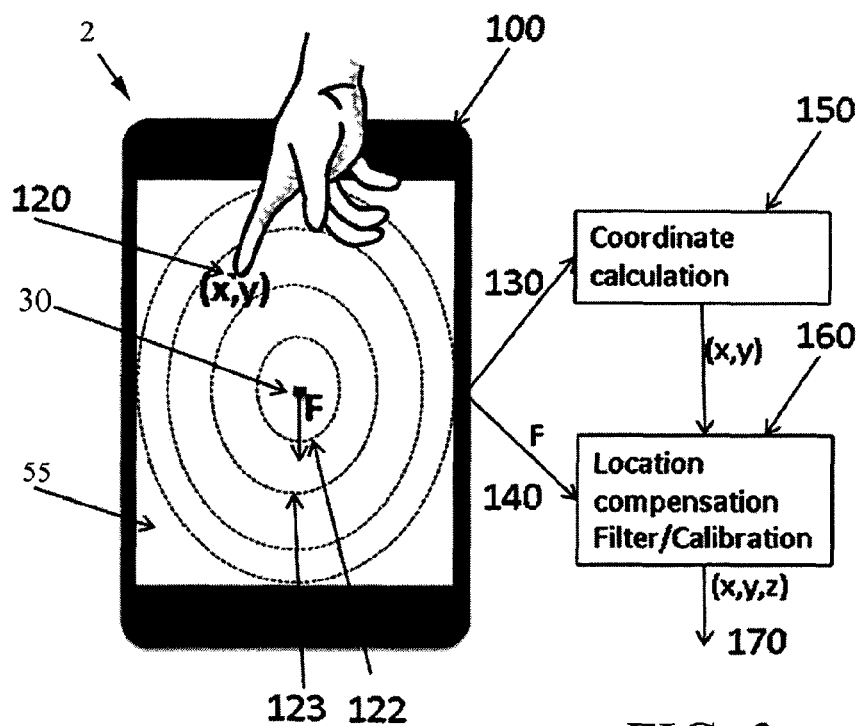
30
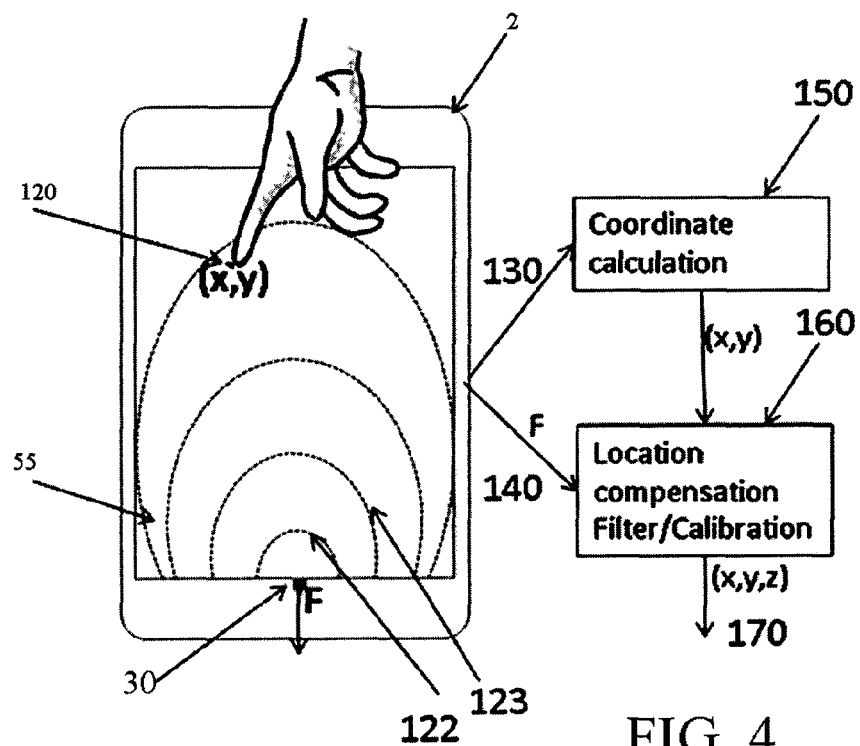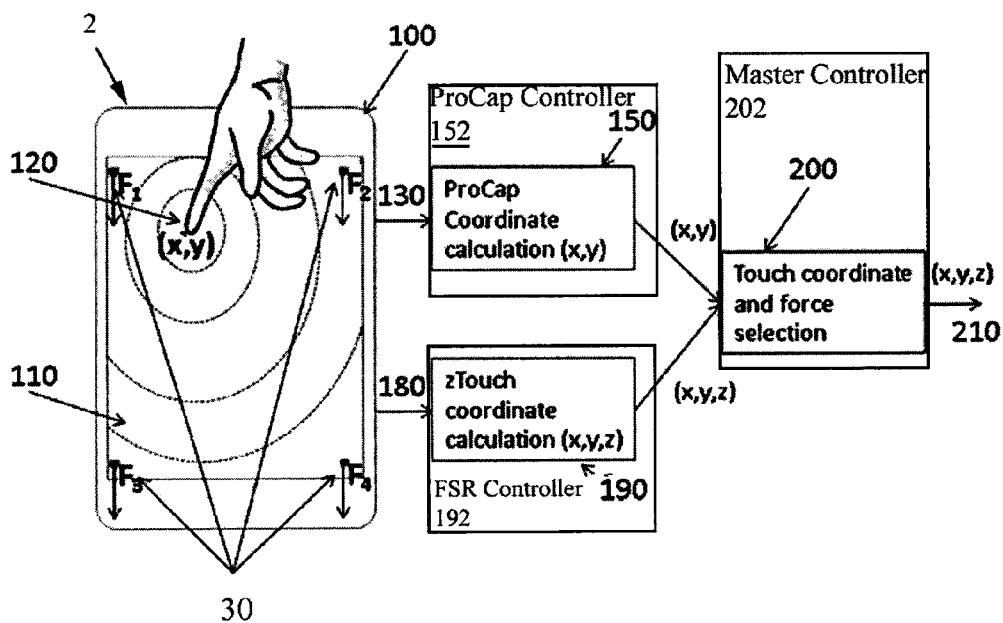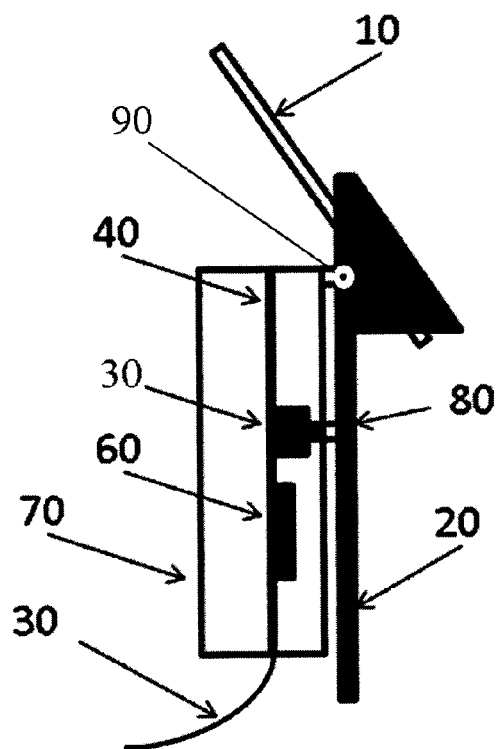
FIG. 6

HYBRID FORCE SENSITIVE TOUCH DEVICES

CROSS-REFERENCE TO RELATED APPLICATION(S)

This application is a nonprovisional patent application of and claims the benefit under U.S.C. §119(e) of U.S. Provisional Patent Application 61/658,020 filed 11 Jun. 2012, and is a continuation-in-part of U.S. patent application Ser. No. 13/425,846 filed 21 Mar. 2012, which is a continuation-in-part of U.S. patent application Ser. No. 12/450,138 filed 11 Sep. 2009, which is a national phase entry of International Application PCT/US2008/003374, filed 14 Mar. 2008, which claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application 60/918,275 filed 15 Mar. 2007, the disclosures of which are hereby incorporated by reference herein in their entirety.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

The present invention relates to touch sensor controls including touch input systems (touch screens used in fixed or mobile devices, such as point of sales terminals, kiosks, laptops, monitors, POS, POI, PDAs, cell phones, UMPCs and the like). More particularly, the invention relates to touch sensor controls having both a touch-coordinate calculation ability as well as a force sensing ability.

(2) Description of Prior Art

The concept of using multiple force sensing sensors to register, measure and triangulate the touched position of a touch screen has been a known concept for more than twenty years, however, to produce a high quality touch screen solution has proven difficult.

Over the last few years the performance trade-offs of the available force sensing technologies has fragmented the market. There are approximately ten (10) different touch screen technologies. However, only one such technology has been adapted to measure both the touch coordinates as well as the absolute amount of touch force. This is "force-based touch screen technology" as described in U.S. patent application Ser. Nos. 13/425,846; 12/450,138; PCT/US2008/003374; and F-Origin's zTouch™ at www.f-origin.com. The other known touch screen technologies include resistive touch-screens (a resistive contact layer allows the position of a pressure on the screen to be read); surface acoustic wave (SAW) technology (uses ultrasonic waves that pass over the touchscreen panel) to register the position of the touch event; capacitive (touching the surface changes capacitance); surface capacitance (change in the capacitance is measured from the four corners of the panel); optical or infrared sensors and LEDs mounted around a display (the sensors detecting a disruption in the pattern of LED beams); acoustic pulse recognition (tiny transducers attached to the edges of the touch-screen pick up the sound of the touch); Dispersive Signal Technology (DST, which consists of a chemically-strengthened glass substrate with piezos mounted on each corner to pinpoint the source of "bending waves" created by finger or stylus contact; and electromagnetic (change in magnetic flux is registered for the system to compute and define the coordinates of the touch event).

In measuring both the touch coordinates as well as the absolute amount of touch force, force-based touch screen technology such as F-Origin's zTouch™ has a great advantage in that software can ensure that the appropriate finger or stylus is touching the touch screen, and inadvertent pressures

can be ignored. There have been a few attempts made to bridge this gap using other touch screen technologies. For example, Stantum™ is using a digital resistive solution that registers a larger touch area (multiple "interference points" in a coordinate grid). The software assumes that it is a finger that is touching the surface and the more touch points that are registering a touch, the larger the force is applied. Unfortunately, this logic fails if the user is using a finger nail or a stylus. Thus, for the time being, force-based touch screen technology retains its advantage. However, there are trade-offs. For example, force-based touch screen technology is only capable of discerning a single touch, and cannot differentiate two or more touches ("multi-touch").

Indeed, all existing touch screen technologies come with a unique set of advantages and disadvantages, and so it is unlikely that any one will completely replace any other.

The most popular touch screen for mobile phones today is the Projective Capacitive (ProCap) touch screen. This technology supports multi-touch and will react to extremely light touches, however, it cannot measure force, nor can it recognize a touch from objects other than fingers or specialized styluses. The following table details the relative strengths and weaknesses of ProCap versus zTouch™ technologies.

Feature	ProCap	zTouch ™	Combined
Multi touch	Yes	No	Yes
Force Sensing	No	Yes	Yes
0-gram touch	Yes	No	Yes
Settable touch thresholds	No	Yes	Yes
Any object touch	No	Yes	Yes
Use with water	Some	Yes	Yes
Use with conductive gels/liquids	No	Yes	Yes
Optical impact	Some	None	Some

Clearly, the ideal solution combines the benefits of both. It would be advantageous to provide a hybrid touch-screen display that integrates force-based touch-screen technology with any one from among a group of projective capacitive, surface capacitive, resistive, digital resistive, SAW, IR, APR, DST, optical and electromagnetic touch-screen technologies. The "Combined" column in the table illustrates the benefits of a combined zTouch and ProCap solution discussed later in this document.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features, and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments and certain modifications thereof when taken together with the accompanying drawings in which:

FIG. 1 is an exploded perspective view of a hybrid touch-screen display employing the foregoing principles.

FIG. 2 is a side cross-section of the touch screen system of FIG. 1.

FIG. 3 is a perspective drawing illustrating an exemplary method of operation of the hybrid touch-screen display of FIGS. 1-2 using one (1) force sensor.

FIG. 4 is a perspective drawing illustrating an exemplary on-plane sensor 30 in the context of a mobile phone with sensor in an alternative location compared to FIG. 3.

FIG. 5 is a perspective drawing illustrating an exemplary method for adding full force-sensing touch screen capabilities to a non-force sensing touch screen.

FIG. **6** is a perspective drawing of an exemplary water dispenser unit, in which a user presses a glass or a cup against a touch lever **20**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention is a hybrid touch-screen display that integrates force-based touch-screen technology with any one from among a group of projective capacitive, surface capacitive, resistive, digital resistive, SAW, IR, APR, DST, optical and electromagnetic touch-screen technologies.

FIG. **1** is an exploded perspective view of a hybrid touch-screen display employing the foregoing principles, and FIG. **2** is a side cross-section of the touch screen system of FIG. **1**. With collective reference to FIGS. **1-2**, the illustrated embodiment employs a Projective Capacitive (ProCap) touch display screen **55**, a support structure **57** for the display screen **55**, and one or more force sensors **30** (here four corner-mounted force sensors **30** shown). The force sensor(s) **30** may be affixed directly (surface-mounted) to the back of the support structure **57** or indirectly (by traces as shown) to a sensor printed circuit board (not shown) which is in turn attached to an opposing base substrate **20** (which may be the back of a device housing).

The touch display screen **55** may be ProCap or any of the other non-force-sensing technologies including any one from among a group of projective capacitive, surface capacitive, resistive, digital resistive, SAW, IR, APR, DST, optical and electromagnetic touch-screen technologies.

One skilled in the art will understand that the system of the present invention requires a control system including non-transitory computer memory, and at least one programmable controller programmed with control software comprising computer instructions stored on the non-transitory computer memory. The control system requires at least one programmable controller for running a first software module for interpreting touch display screen **55**, a second software module for interpreting sensors **30**, and a third software module for interfacing the first and second software modules and for reconciling the results. As described more fully below, these modules may reside on two or more separate controllers, for example, one for touch display screen **152**, one for FSR sensors **30**, and one for the reconciliation software module.

The edges of the touch display screen **55** may be protected by a front-mounted frame or bezel **50** as shown, although the touch surface of the touch display screen **55** remains exposed through frame **50**. Optional rubberized padding **53** may be placed as shown underlying the frame **50** and adhered thereto. The padding **53** may be a continuous rectangular gasket made of Poron™ for example, which helps to cushion the touch display screen **55** and imposes a spring-like preloading force to minimize the impact from shock and vibration. As an alternative to a continuous gasket, a continuous silicon membrane may be used for liquid/water proofing as well as providing pre-loading **53**. The pre-loading can however also be provided by added spring elements such as two flat spring arms (not shown). The maximum allowed movement, as allowed by the internal compression of the sensors **30** and the padding **53** is typically between 0.01-0.03 mm, but may be somewhat larger depending on sensor type, padding material and operational force range. Similarly, optional rubberized damping pads **56** may be placed as shown underlying the sensors **30** and adhered thereto.

The one or more force sensor(s) **30** may comprise any conventional force-sensing resistive (FSR) sensors, piezo resistive sensors, or FTR (force transducing rubber) sensor.

FSR sensors are typically made up of two plans of conductive materials "connected" through FSR material. Different types of resistive materials may be used. The common characteristics of the FSR material are that it remains non-conductive until a force is applied. When a force is applied, the resistance in the material decreases as the applied force increases. Modular FSR sensors are commercially-available. In addition, for higher accuracy system, piezo resistive force sensors, such as the HFD-500 force sensor **30** available from HDK™ can be used. It comes in a small resin mold package with a $\frac{1}{16}$ inch steel ball in contact with the silicon wafer (the piezo sensor). The HFD-500 Micro-Force Sensor can detect changes in applied force of one gram force or less. The single-axis device uses a piezo resistive sensor (crystal silicon sensor chip) that changes its resistance as a function of the pressure applied through the steel ball, creating a proportional output signal via internal bridge circuitry. Sensitivity for these types of sensors is typically in the 10 to 20 mV/N with a linearity of ±3% with a 3V supply current.

FTR is a polymer thick film (PTF) commonly used for keyboard applications. Any other suitable force sensor, such as for example, capacitive force sensors may also be used.

Given at least one centrally-mounted force sensor **30**, the sensor **30** is capable of registering absolute force F_z along the z-axis orthogonal to the plane of the touch screen display **55**. Given a plurality (such as, for example, four) differentially corner-mounted force sensors **30**, each sensor **30** registers a different force as a function of the two-dimensional (x, y) coordinates along the plane of the frame **50**. By calculating the differential pressure at the corners the exact coordinate of the actual touch can be calculated.

FIG. **3** is a perspective drawing illustrating an exemplary method of operation of the hybrid touch-screen display of FIGS. **1-2** in the context of a mobile phone **2**, using a single centrally-mounted force sensor **30** implemented underneath the touch display screen **55** of the mobile phone **2** at point F. Note that for most mobile phones the LCD display and the touch display screen **55** are combined into a single module, most often together with additional layers, such as protective surface glass and anti-reflection coating, etc., and touch display screen **55** represents this module. As a user touches the touch display screen **55** surface at point **120**, the ProCap (or other) touch display screen **55** itself transmits the exact two-dimensional (x, y) touch coordinates along the plane of the touch display screen **55**. In addition, a component of the force of the touch is transferred through the touch display screen **55** to the force sensor **30** behind the screen **55**, and the absolute touch pressure can be computed as will be described.

The touch display screen **55** is preferably implemented to allow for a very small movement/flexing along the z-axis, typically in the range of one or a few $\frac{1}{100}$ mm. Thus, given the user touch at point **120** (FIG. **3**), the exact two-dimensional (x, y) touch coordinates known from the non-force-sensing (ProCap or other) touch display screen **55**, and the z-axis force component F_c known from the force sensor(s) **30** behind the module, then in accordance with the present method at block **150** the processor computes the absolute touch pressure Fz. In order to reach an optimal performance, at block **160** the sensor data is filtered based on the z-axis force component F_c from block **150**, to filter out unintentional or inadvertent touches (light pressures), or shock or vibration.

One skilled in the art should readily understand that it is also possible to place the sensor **30** on plane with the touch panel **55** by keeping it outside of the actual touch area.

FIG. **4** is a perspective drawing illustrating an exemplary on-plane sensor **30** in the context of a mobile phone **2**, here

using a single offset-mounted force sensor **30** implemented below the touch display screen **55** of the mobile phone **2** at point F.

It is virtually impossible to implement a touch system where the absolute touch pressure Fz from touch panel **55** transfers perfectly and without any frictional or bending forces directly to the force sensor **30**, especially as such mechanical provisions will consume space, which is very limited in a mobile phone **2** or most consumer electronics. Instead, the present system is pre-programmed to compensate for non-perfect force transfer. Thus, to compute the absolute touch pressure Fz at block **150** (FIG. **3** or **4**), the processor software may subdivide the touch area of touch panel **55** into different zones or "force rings" **122**, **123**, etc. For example, when a user touches the touch area at point **120** with force Fz (near the sensor **30**) it occurs within zone **122**. At this point **122** the sensor **30** will register a relatively higher force Fc than if the user had touched the touch panel **55** with exactly the same force Fz in the next zone further away **123**. This imperfect translation problem can however be compensated for based on the ProCap touch coordinates (x,y) and a predetermined coordinate force mapping. Specifically, a pre-determined compensation factor C may be used. For example, when a user touches the touch area at point **120** and sensor **30** reads force Fc (near the sensor **30**) within zone **122**, the processor may attribute a compensation factor of 1.1 and multiply 1.1×Fc to attribute an absolute touch pressure Fz. The closer a touch is applied to the sensor **30** location, the higher the force Fc will be registered, and the smaller the compensation. Conversely, when a user touches the touch area within zone **123** and sensor **30** reads force Fc (further from the sensor **30**), the processor may attribute a compensation factor of 1.3 and multiply 1.3×Fc to attribute an absolute touch pressure Fz. The entire touch surface of touch screen display **55** is mapped into zones in this manner. Depending on the nature of the mechanical implementation, this compensation can be added as a compensation matrix (look-up table) or pre-defined compensation equation (as function of touch coordinate). Once the absolute force Fz is calculated from compensated Fc, a three dimensional touch coordinate (x,y,Fz), or simply (x,y,z), can be exported to the operating system and/or overlaying applications. The (x,y,z) coordinate output can easily support gestures, such as a line drawing where the z-coordinate can add another dimension, such as line thickness as a function of applied force. In addition, a time stamp can be exported and combined with the (x,y,z) coordinates by the operating system. The absolute force component Fz is combined with coordinates (x,y) to yield (x,y,z) and all may be time-tagged (x_{t1}, y_{t1}, z_{t1}) at block **150**, to ensure that the correct coordinates are used for force compensation of the correct force and later paired together in matching sequence.

It should be noted that the force compensation and calculation in block **150** is completed in real time in milliseconds or less.

Moreover, given (x,y,z) coordinate output it now becomes possible to filter out very light and unintentional touches at block **160**. If for example the user brushes the display accidently with a finger at a very low force, such as 5 grams, the force sensor **30** measures a force of 2.1 gram at a specific time, t1. The force compensation based on the touch zone (**122**, **123**, etc.) is added and the compensated force z_{t1} is estimated to 5 grams.

The result (x1, y1, 5 gram)^{t1} is checked against pre-programmed touch thresholds, such as for example a minimum

threshold of 15 grams. In this case the touch coordinate (x1, y1, 5 gram) for t1 is not communicated up to the operating system.

One skilled in the art may recognize that adding full force-sensing touch screen capabilities as described above to a non-force sensing touch screen technology will require a software implementation that accommodate pre-existing dedicated software modules, working in conjunction with additional software.

For example, FIG. **5** is a perspective drawing illustrating an exemplary method for adding full force-sensing touch screen capabilities to a non-force sensing touch screen in the context of a mobile phone, using four corner-mounted force sensors **30** implemented underneath the touch display screen **55** of the mobile phone **2** as in FIG. **2**. This entails a reconciliation software module **200**. Essentially, a first software module **150** is used to calculate coordinates (x,y) for the non-force-sensing (ProCap or other) touch display screen **55**, a second software module **190** obtains the z-axis force component F_c known from the force sensor **30** behind the module, and third reconciliation software module **200** performs force Fc compensation, calculation of three dimensional touch coordinates (x,y,z), and time tagging for export to the operating system, and/or overlaying applications. The system represented by FIG. **5** presumes an existing ProCap touch panel **55** with its own dedicated controller **152**, plus a separate zTouch™-type FSR system with four sensors **30** having their own dedicated controller **192**, controllers **152** and **192** interfacing at reconciliation software module **200**. The software modules **150**, **190** may be firmware and may reside on respective processors **152**, **192**, and module **200** may be firmware resident on either processor **152**, **192** or on a third master controller **202**, most likely, a main system processor. Both coordinate calculations are communicated to master controller **202**. The ProCap controller **152** runs the first software module **150** and is dedicated to calculating ProCap coordinates (x,y) for the non-force-sensing touch display screen **55**. For example, as seen in FIG. **5**, the zTouch™ controller **192** runs the second software module to obtain zTouch™ coordinates plus the z-axis force component F_c known from the force sensor **30** behind the module (x,y,z). The main system processor **202** runs the third reconciliation software module **200** and performs force Fc compensation, comparison of the ProCap coordinates (x,y) with zTouch™ coordinates (x,y,z), filtering of the two sets of touch coordinates (x,y,z), and time tagging for export to the operating system, and/or overlaying applications. In this case touch decisions made by master controller **202** may include the following:

If the force component z in the zTouch™ coordinate calculation is less than F, do not export coordinates.

If the Procap(x,y) and zTouch™ (x,y,z) coordinates are both known, use the (x,y) coordinate from ProCap, combine with force component from zTouch™ coordinate (x,y,z) and export the new (x,y,z) coordinate **210**.

If only the x,y coordinates from the zTouch™ coordinate calculation **190** are known (then it is likely that the user is using a stylus), use only the zTouch™ coordinates (x,y) for the final coordinate (x,y,z).

If the Procap (x,y) coordinates match a pattern associated with interference from water or conductive liquid, disregard the ProCap coordinates **150** and use only the zTouch coordinates (**190**).

Note, if there is no applied force Fc, ignore coordinate input.

If multi touch, multiple (x,y) coordinates are recognized at the same time, only use the force loading of the zTouch™ coordinate calculation **190**.

As described above with regard to FIGS. 3-4, the four force sensors 30 in the multi-touch system of FIG. 5 may be placed outside of the touch panel 55 display area, in-plane with the touch panel 55, in the same way.

It should now be apparent how adding the force dimension z to the touch coordinates x,y improves the information sent to the operating system/overlying applications, and will allow for additional functionality. One skilled in the art may foresee additional features or feature enhancements attainable by adding force-sensing capability in parallel with a different touch screen system, such as a ProCap touch system, and such additional features or feature enhancements are considered within the scope and spirit of the invention.

It should also be apparent that the above-described embodiments all involve a hybrid implementation of a zTouch force-sensing technology with a suitable non-force sensing touch screen technology. However, in its most basic implementation, the present invention may comprise one single force sensor and zTouch™ firmware running on a processor or microcontroller.

As an example, FIG. 6 is a perspective drawing of an exemplary water dispenser unit, in which a user presses a glass or a cup against a touch lever 20. Lever 20 is hinged to a main housing through a hinge mechanism 90. The touch force from the glass is transferred via any suitable force transfer feature 80, such as a spring-loaded detent, or other suitable mechanical feature allowing the force to be transferred to a sensor housing 70 at a single point. The force is transferred through the flexible wall/membrane of the sensor housing 70 directly onto a force sensor 30. Prior art implementations use an on/off switch incapable of relative force measurement. Here, the increased touch force from the glass will result in an increased voltage output from the sensor 30 which preferably resides on a sensor PCB 40. The analog signal from sensor 30 is amplified and sent into a micro controller 60 which may also reside on the PCB 40. The microcontroller 60 will convert the analog (voltage) data to digital input data. The above-described firmware runs on the microcontroller 60 and interprets and filters the touch data. The added force-sensing ability of sensor 30 allows additional software features in the firmware that can always ensure that the system is auto-calibrated in between touches, and to determine if a touch is an actual touch or just a temporary static load by analyzing the force pattern. Permanent changes in static load, for example if the touch panel is removed and replaced with a new part which adds a slightly different static load, can be easily compensated. The delta load can be calibrated out and ignored through firmware calibration.

Once the firmware on the microcontroller 60 determines that the added force to the touch panel 20 is the result of a true touch of a glass, the result or command is communicated via any suitable data communication to a water flow controller or pump that will open up the water flow in the water line 10.

The above-described implementation is but one example of a single force sensor control unit in a water dispenser unit, but other implementations are possible where the functional purpose may be completely different, mechanics may look different, and the zTouch™ firmware may reside in a shared processor running as an integrated part of the system code. Additional implementations or feature enhancements to existing implementations are considered within the scope and spirit of the invention.

Having now fully set forth the preferred embodiment and certain modifications of the concept underlying the present invention, various other embodiments as well as certain variations and modifications of the embodiments herein shown

and described will obviously occur to those skilled in the art upon becoming familiar with said underlying concept. It is to be understood, therefore, that the invention may be practiced otherwise than as specifically set forth in the appended claims.

What is claimed is:

1. A touch-sensitive display assembly adapted to calculate coordinates of a touch in a coordinate plane as well as a force of the touch along a z-axis, the touch-sensitive display assembly comprising:
   a housing;
   a frame coupled to the housing;
   a touch display screen in the housing and exposed through the frame, the touch display screen adapted to calculate coordinates of the touch in a coordinate plane using one or more sensors;
   a support structure underlying the touch display screen;
   at least one force sensor underlying the support structure, the at least one force sensor adapted to determine a force of the touch perpendicular to the coordinate plane; and
   a control system comprising a non-transitory computer memory for storing instructions for:
      determining the coordinates of the touch in the coordinate plane from the touch display screen;
      determining a force component of the touch perpendicular to the coordinate plane from the force sensor;
      subdividing an area of the touch display screen into a plurality of concentric areas; and
      computing an absolute touch pressure at the determined coordinates in the coordinate plane by compensating the force component as a function of the predefined concentric area within which the touch occurred.

2. The touch-sensitive display assembly according to claim 1, wherein the at least one force sensor is a corner-mounted force-based sensor.

3. The touch-sensitive display assembly according to claim 1, wherein the at least one force sensor is surface-mounted on the back of the support structure.

4. The touch-sensitive display assembly according to claim 1, wherein the at least one force sensor is mounted on a printed circuit board inside the housing.

5. The touch-sensitive display assembly according to claim 1, further comprising rubberized padding between the housing and touch sensitive display screen.

6. The touch-sensitive display assembly according to claim 5, wherein the rubberized padding comprises a continuous rectangular gasket.

7. The touch-sensitive display assembly according to claim 6, wherein the continuous rectangular gasket comprises silicon.

8. The touch-sensitive display assembly according to claim 6, wherein the rubberized padding imposes a predetermined preload force to the touch sensitive display screen to minimize impact from shock and vibration.

9. The touch-sensitive display assembly according to claim 1, wherein the at least one force sensor comprises a force sensing resistive sensor.

10. The touch-sensitive display assembly according to claim 1, wherein the at least one force sensor comprises a piezo resistive sensor.

11. The touch-sensitive display assembly according to claim 1, wherein the at least one force sensor comprises a force transducing rubber sensor.

12. The touch-sensitive display assembly according to claim 1, wherein the control software ignores a touch if the absolute touch pressure is below a predetermined minimum threshold.

13. The touch-sensitive display assembly according to claim **1**, wherein the control software computes a first set of touch coordinates from the force sensing sensors, and a second set of coordinates from the touch sensitive display screen.

* * * * *